COAL IN SUSTAINABLE SOCIETY

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Coal in a Sustainable Society

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Abstract

The greenhouse issue has focused attention on coal's environmental credentials, and its role in the transition to a sustainable society. However, it is important to recognize that most of the world's people still depend on coal for most of their power and steel.

LCA and other systems analysis tools are being used increasingly to quantify and identify improvement options throughout energy chains. In the next 10-15 years it is likely that GGEs associated with steel production and electricity generation will decrease by 30% per unit of output, both through incremental and new technologies – the technology is either in place, or in the final stages of development.

For both electricity and steel production, there are important synergies with the cement industry, and industrial ecology (by-products of one industry being used as inputs to another) can lead to synergies with other industries.

In addition to considering greenhouse gas emissions from coals use, issues such as fresh water consumption, particulates and arsenic/fluoride emissions (human health impacts) need to be considered.

Fresh water consumption for electricity generation (approximately 4 t/t of coal), will reduce as the efficiency of coal utilisation increases: there is a virtuous cycle – improved efficiency reduces GGE, water consumption, particulates, SO_X and NO_X. Human health impacts, usually associated with direct coal use for cooking and heating in homes in developing economies, can be overcome by (for example) increased availability of electricity.

The comparison of energy technologies, to enable society to evaluate options on an objective basis, requires values to be placed on externalities. In addition to LCA-type approaches, the EU have developed a methodology which costs the impacts associated with GGE, NO_X, SO_X and suspended particulates for energy production systems (note that fresh water use was not included). Since technology exists to substantially reduce NO_X, SO_X and suspended particulates, GGE will remain as the major strategic issue for coal use.

While the magnitude of the role of coal in the transition to a sustainable society can be debated, there can be no doubt that coal will continue to be a major source of energy and reductant. However, society will require that coal is used more efficiently and with less impacts. The many opportunities for improvement through the coal chain can only be addressed by participants working cooperatively. There is also scope to couple renewables with coal, and overcome the separation that has limited synergies in R&D and the effectiveness of commercial operations.

The availability of coal, its ease of storage and cost advantages, underpin energy security in many economies. The economic benefits of coal use will help fund the transition to a less carbon intensive society, whether by increased coal use efficiency, increased use of renewables, or sequestration, or a combination of all of these. The many improvement options for coal can also give low cost CO_2 abatement.

Life with coal will continue to pose challenges, while at the same time providing energy security, supporting economic development and underpinning the development of renewables.

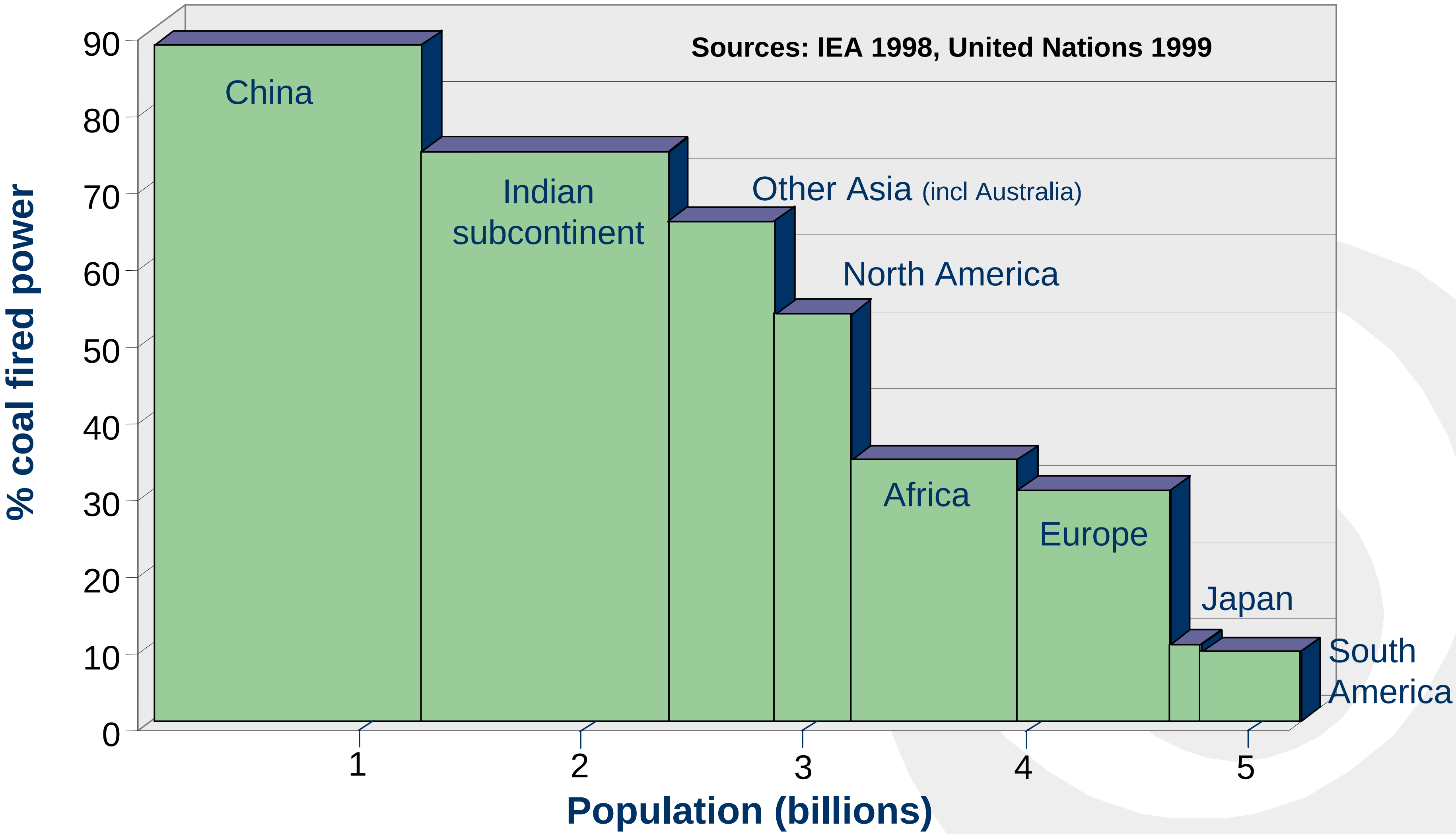
Coal in a sustainable society

Louis Wibberley

Coal in a Sustainable Society

Coal facts 2001

"Most of the world's people depend on coal for most of their power"



Context

- Coal faces significant challenges …
  - environmental, political and community perceptions
  - negativity towards coal is based on superficial "burner tip" comparisons (a poor basis for policy formulation)
  - but … policy dilemma - how to meet the development needs of the world in a sustainable, affordable manner
- ... but coal will have a key role to play
  - coal is expected to underpin future energy demand (large reserves, diversity of supply, stability of price, ease of storage)
  - although coal consumption is expected to increase, the proportion of the total energy is expected to decrease
  - renewables need a base load energy source

Value chain assessment

- Requires systems analysis, from coal in the ground through to waste disposal
  - life cycle analysis (LCA) and ExternE are supporting tools
- LCA
  - starts with an inventory of inputs /outputs which provides data for assessing impacts
  - useful for comparing/improving processes
  - leads to an understanding of process chain and technology
- Another approach is to value in $ (*eg* ExternE)
  - extension of LCA impact assessment
  - total costs of environmental impacts on a regional basis
  - understanding of overall economics of options
- Both approaches have limitations and continue to be developed

Iron and steelmaking

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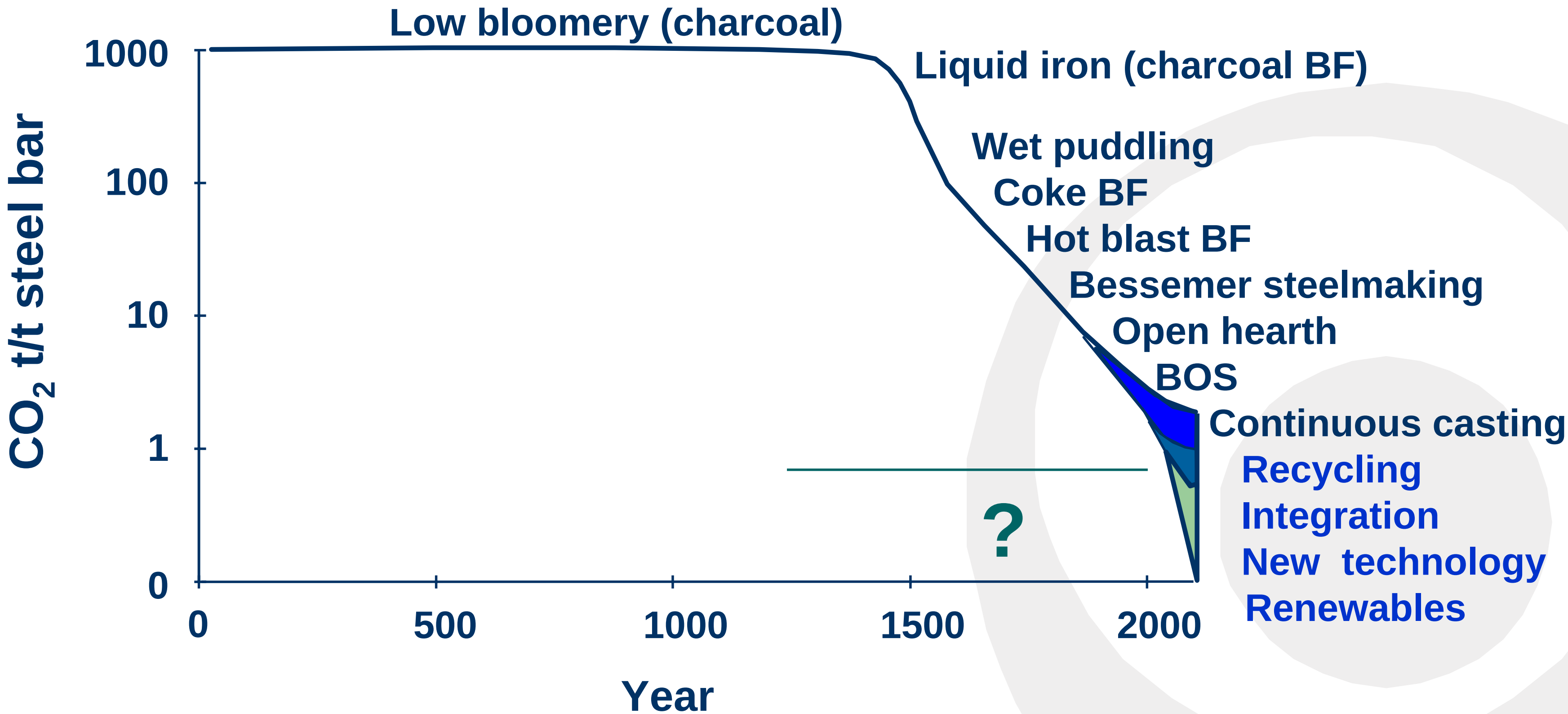
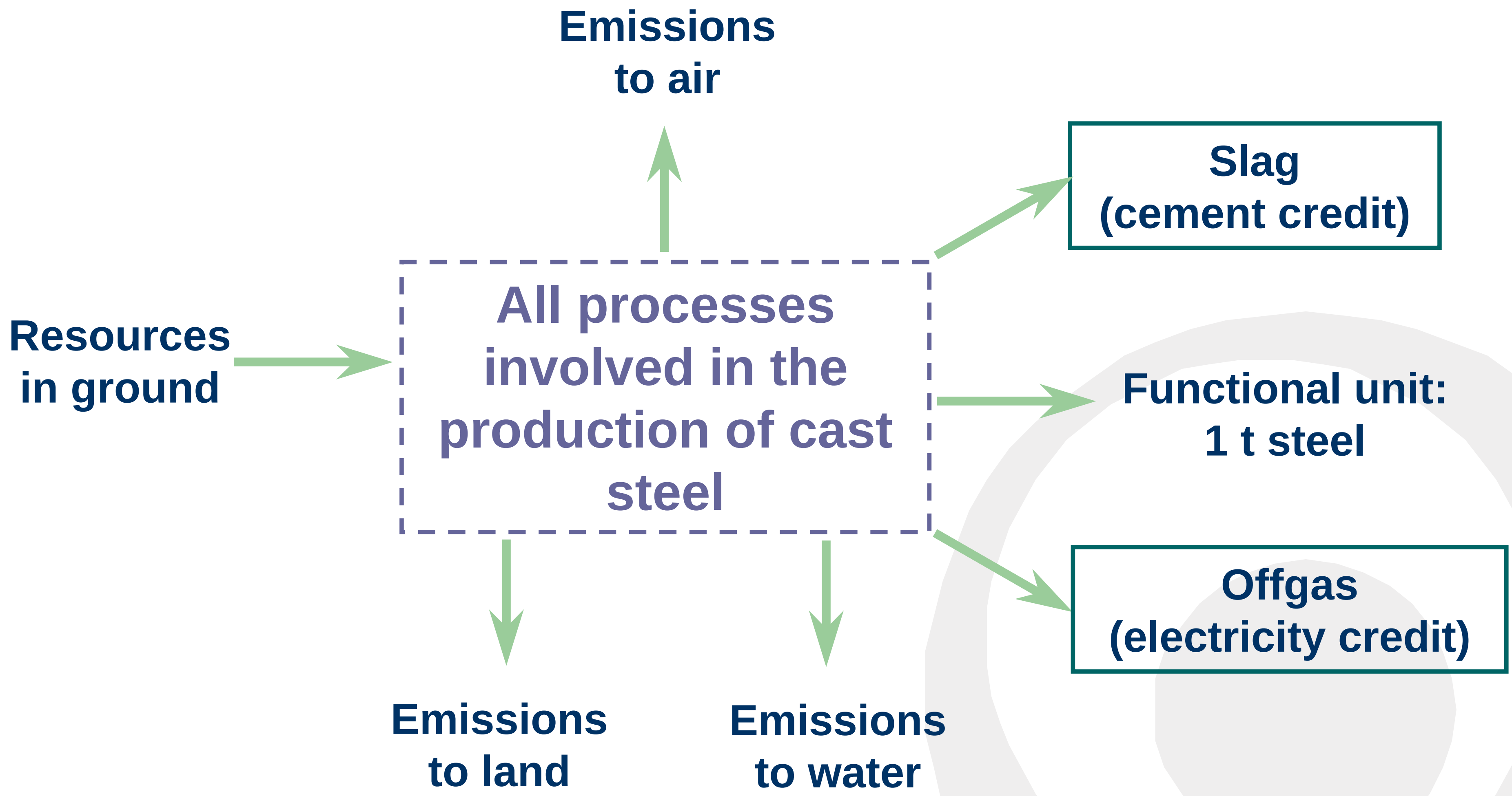
Historical perspective – iron and steel

- Impressive process improvements have been made by the steel industry over time, by both breakthrough and incremental technology development



Steel GGE (t CO_2-e/t cast steel)

- a systems or holistic approach is required



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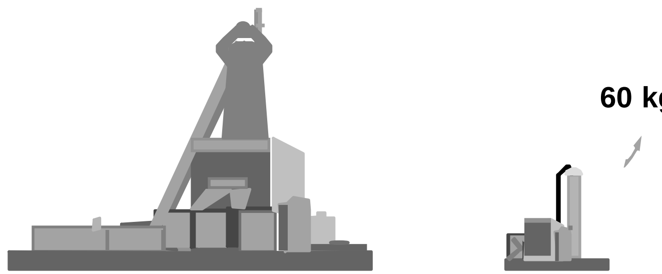
Displacement credits - slags

a) BF slag processing system
(basis 3,500 kg hot metal)

60 kg CO_2



Blast furnace **Slag grinding**

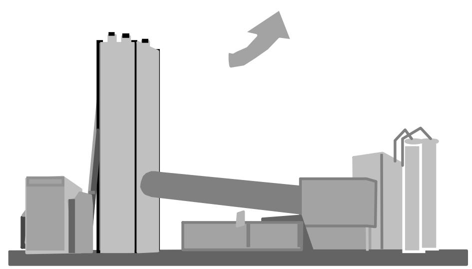
BF slag cement
GGE 60kg CO_{2}-e
(equivalent to 1,000kg of Portland cement)

1,000kg

b) Cement system

Limestone and shale quarrying

1,020kg CO_2



Cement plant
(includes clinker grinding)

Portland cement
GGE 1,020 kg CO_2-e

1,000kg

No technical or economic issues

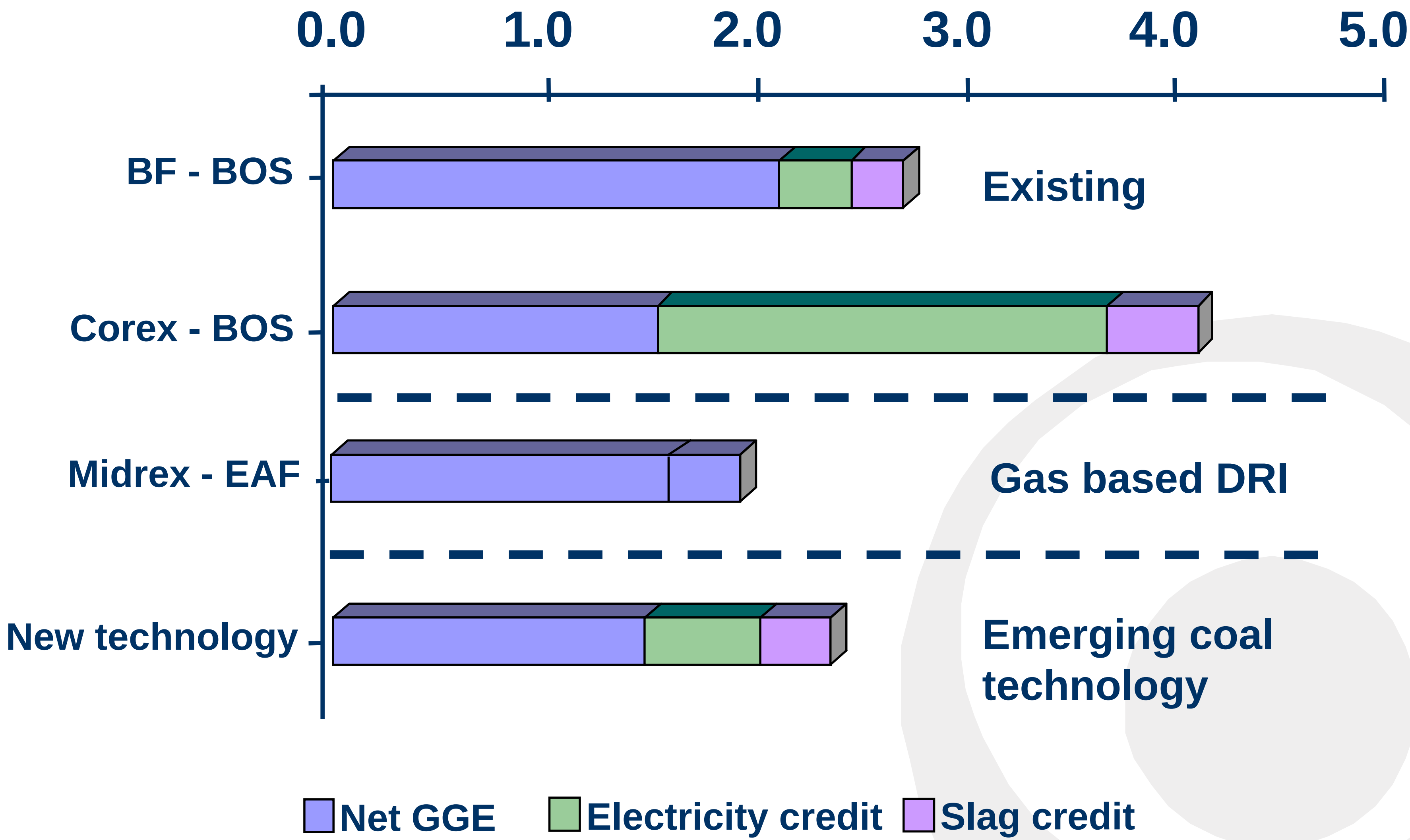
Often limited by attitudes

A product stewardship issue for <u>both</u> coal and steel

Displacement credits - offgases

- Almost entirely utilised for both heating and electricity generation – but the displacement credit for electricity is highly dependent on the efficiency and energy mix of the grid
  - low CV gas (eg BF gas) can give a negative credit (ie worse) when used for electricity generation
  - best for high CV gas used in combined cycle gas turbines
- Incorrect assumptions, especially for some of the new ironmaking technologies which generate considerably more offgases can give highly misleading GGE values

Steel GGE (t CO_2-e/t cast steel)



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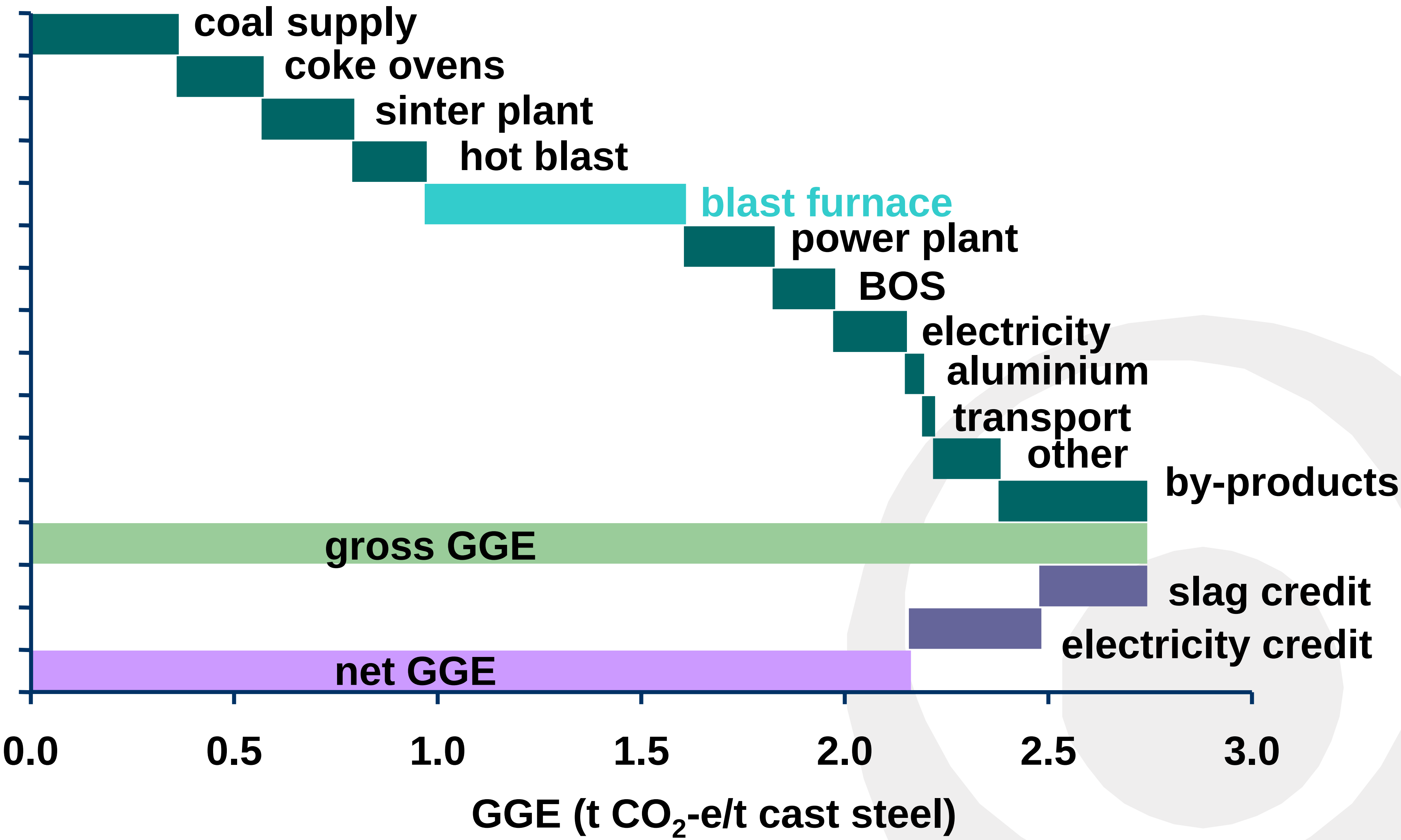
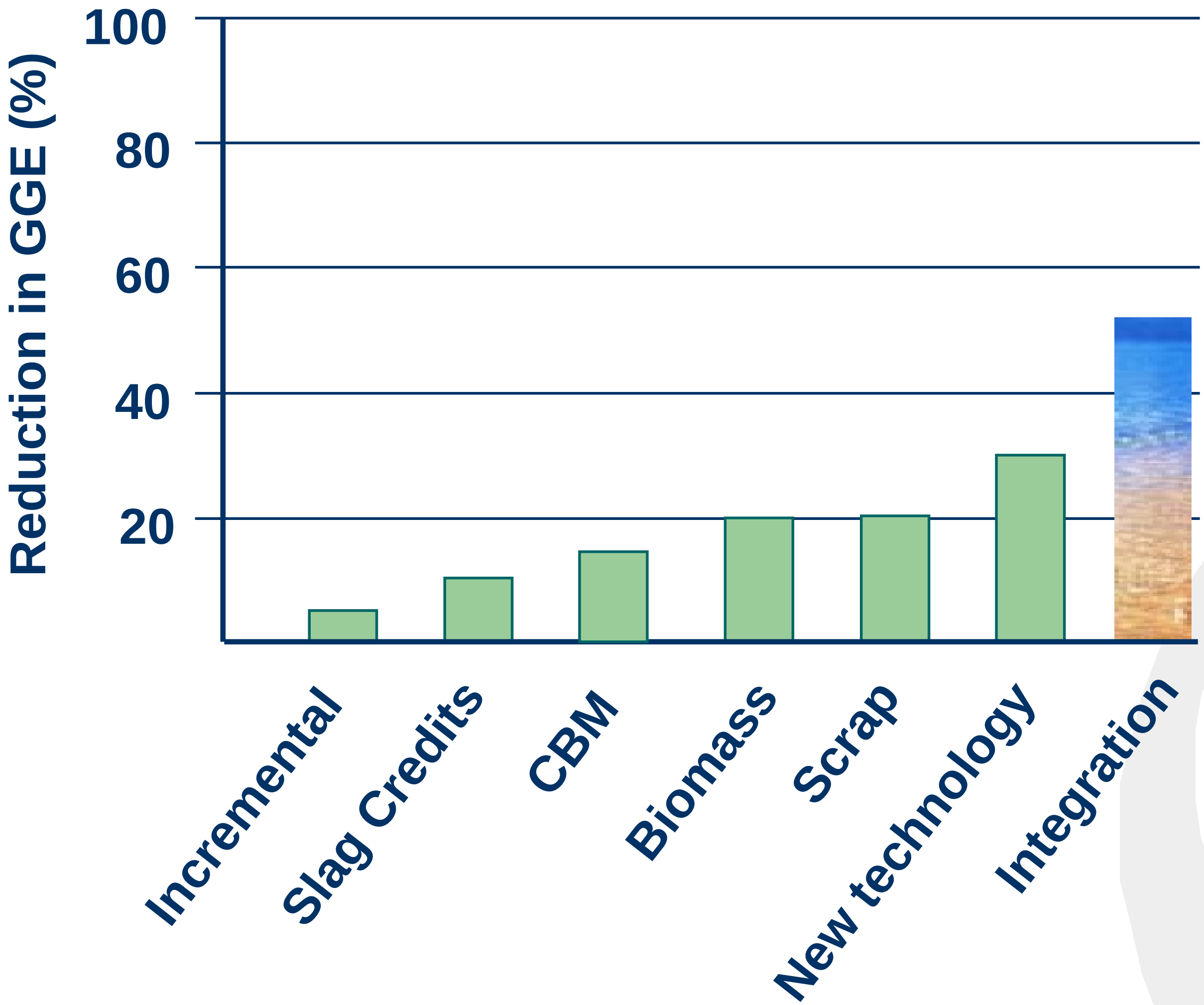
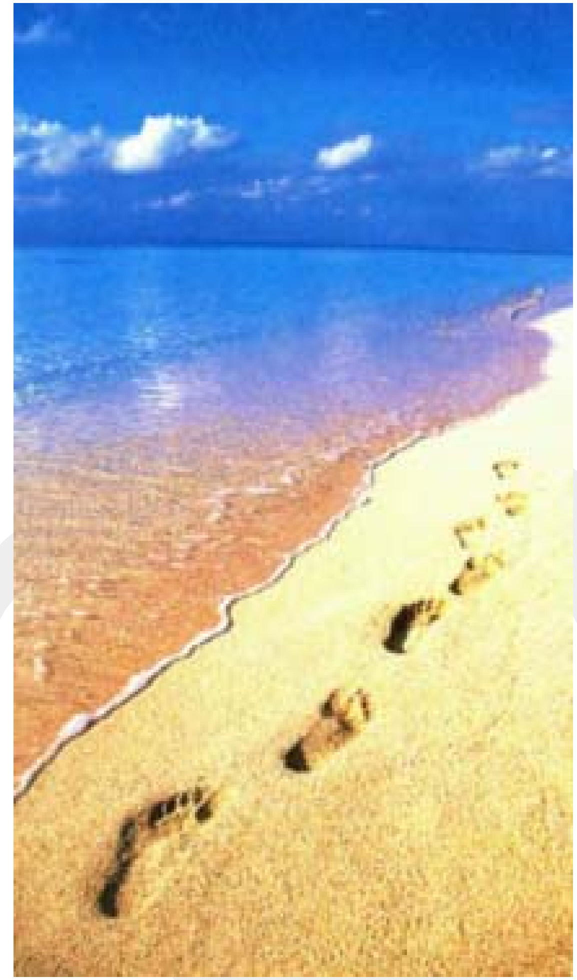
Blast furnace only one source of GGE

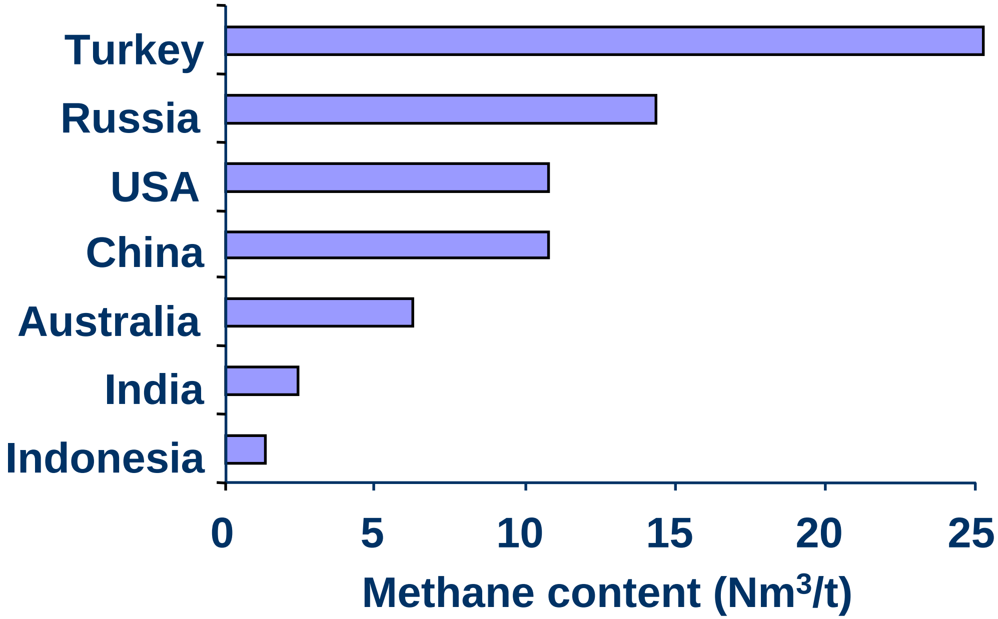


Improvement opportunities

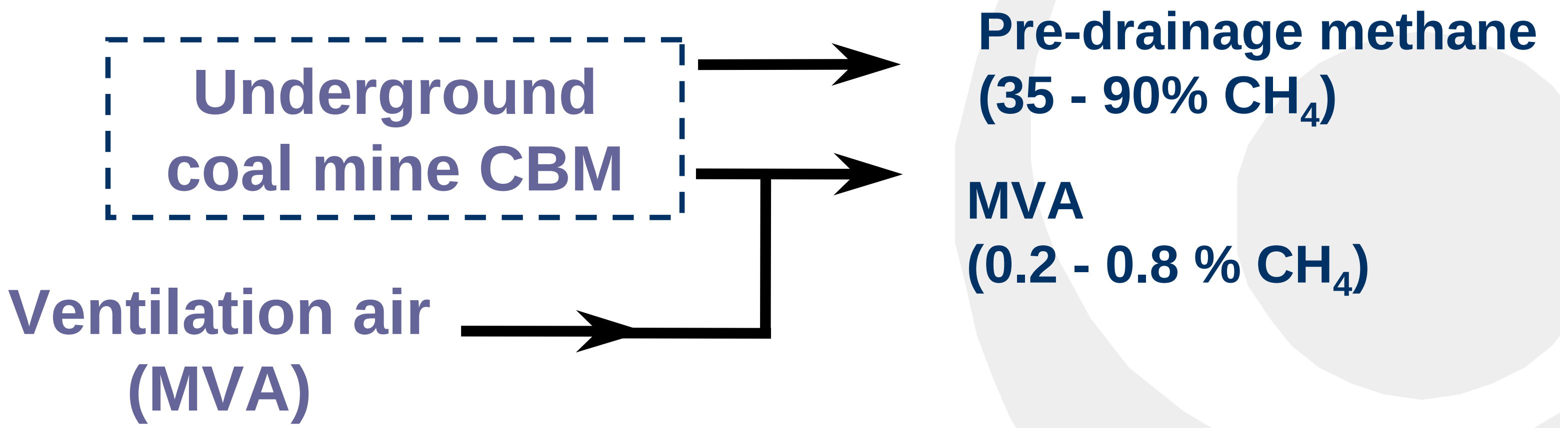




Coal bed methane (CBM)



- World total 30 Mtpa?
- only 5% utilisation
- ~50% as MVA for underground mines
- biggest GGE benefit from oxidation, power gives small additional benefit



CBM utilisation at Appin & Tower

- 94MWe using $1MW_e$ gas engines
- 160kt/a CH_4 utilised (pre-drainage gas, some MVA used as combustion air)
- 3Mt CO_2-e avoided annually

MVA oxidation at Appin

- MEGTEC 340kW Vocsidizer unit
  - supported by ACARP
- Combusts methane in MVA
  - $4000 Nm^3/h$
- Stage 2 to include power generation
  - GGAP funding

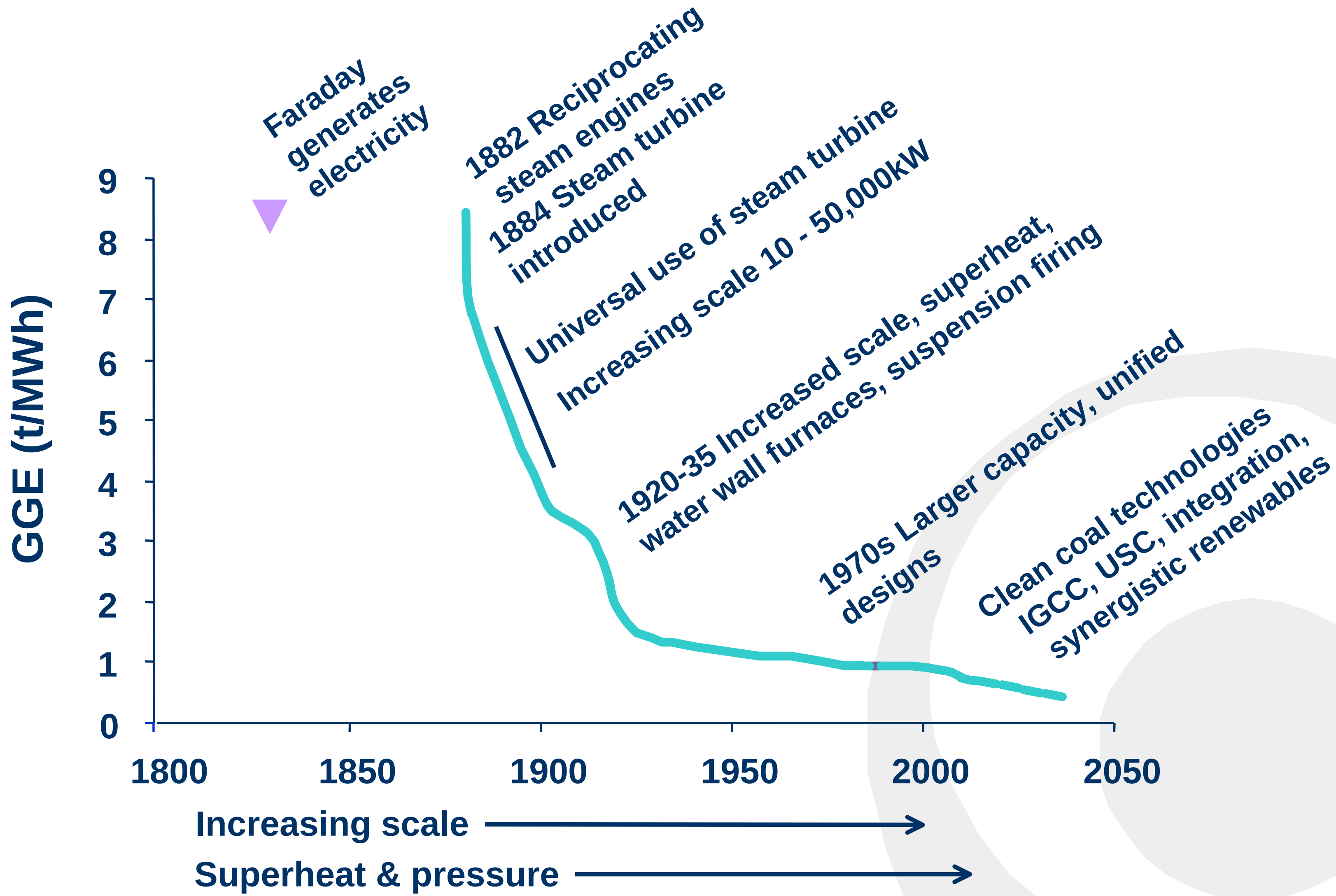
Charcoal – limited applicability

Charcoal trials at Corrimal

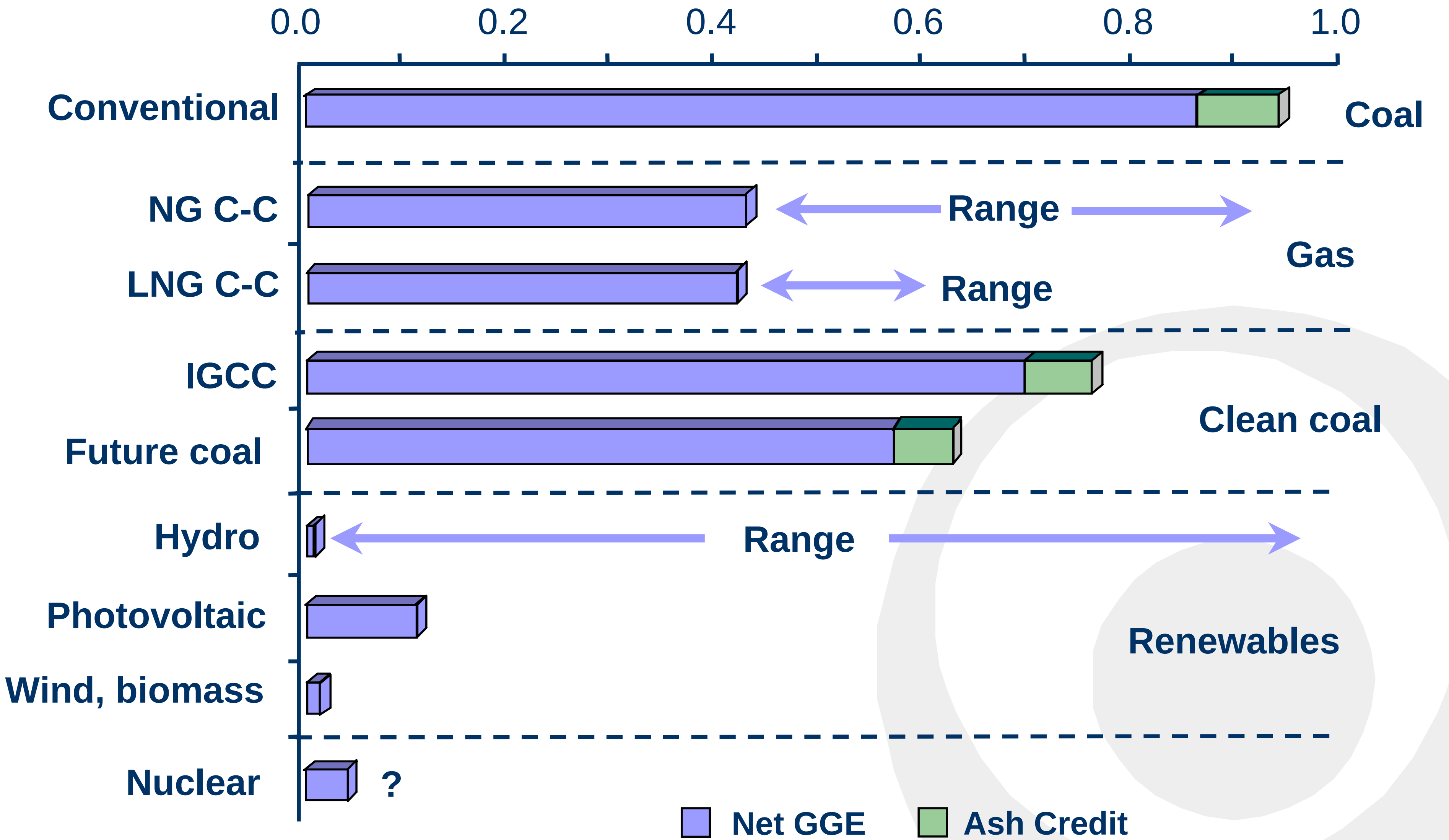
- Cost $350-500/t
- Niche markets already economic (*eg* recarburiser is 10-20kt/a in Aust)
- Biomass to generate electricity is a more effective approach
  - less transport
  - more flexibility in biomass type

Electricity generation

Historical perspective



Electricity GGE (t CO_2-e/MWh)



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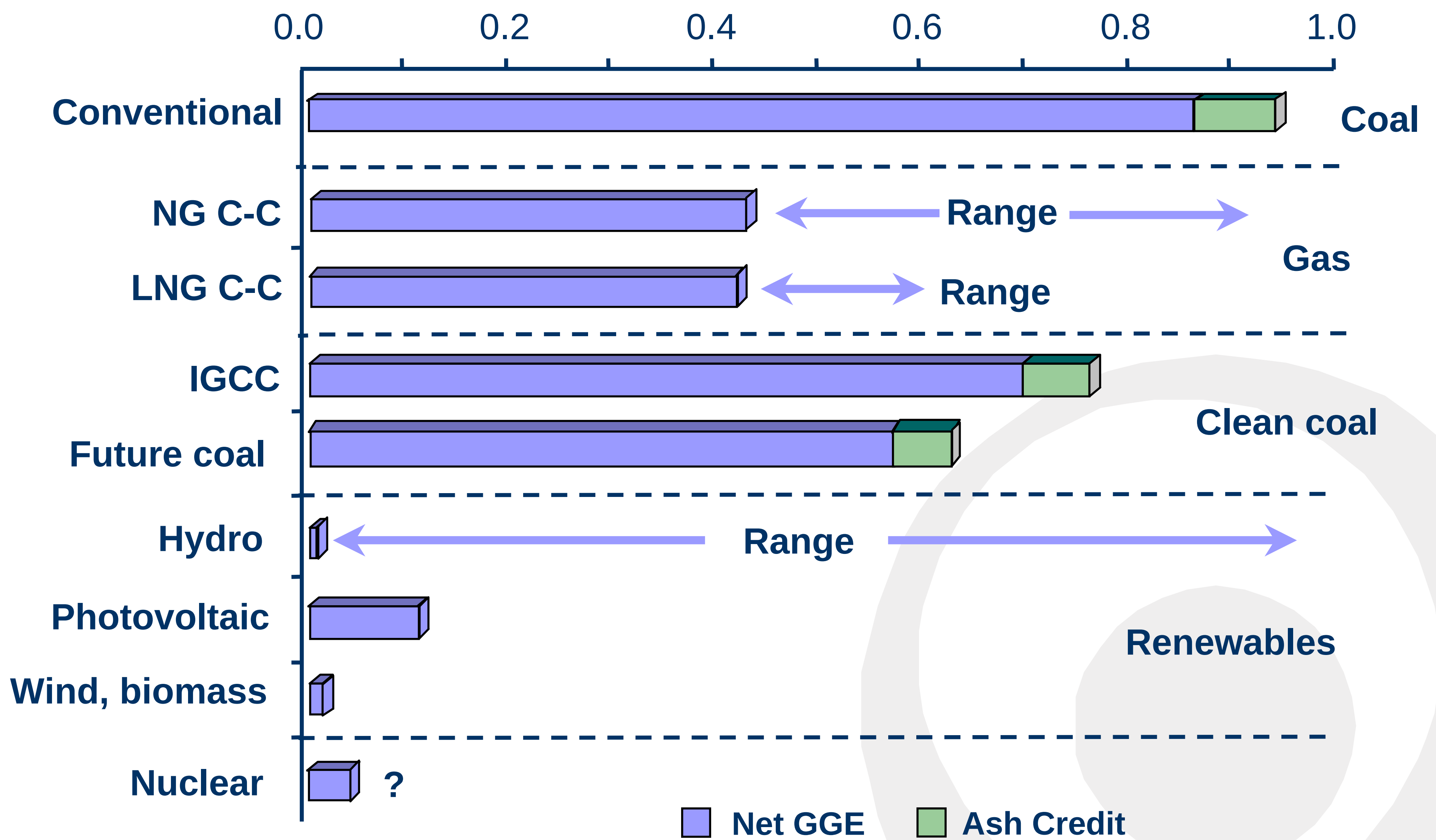

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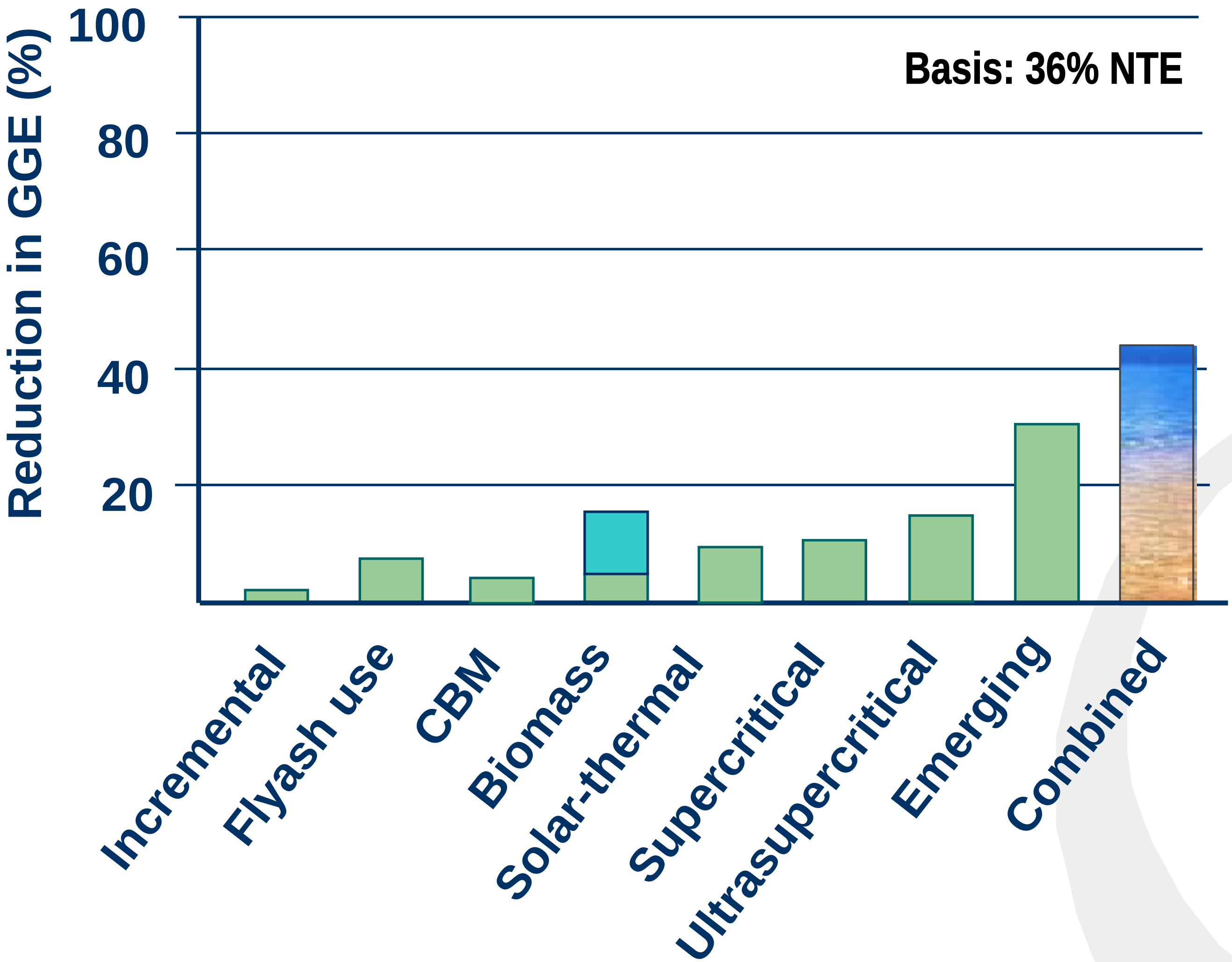
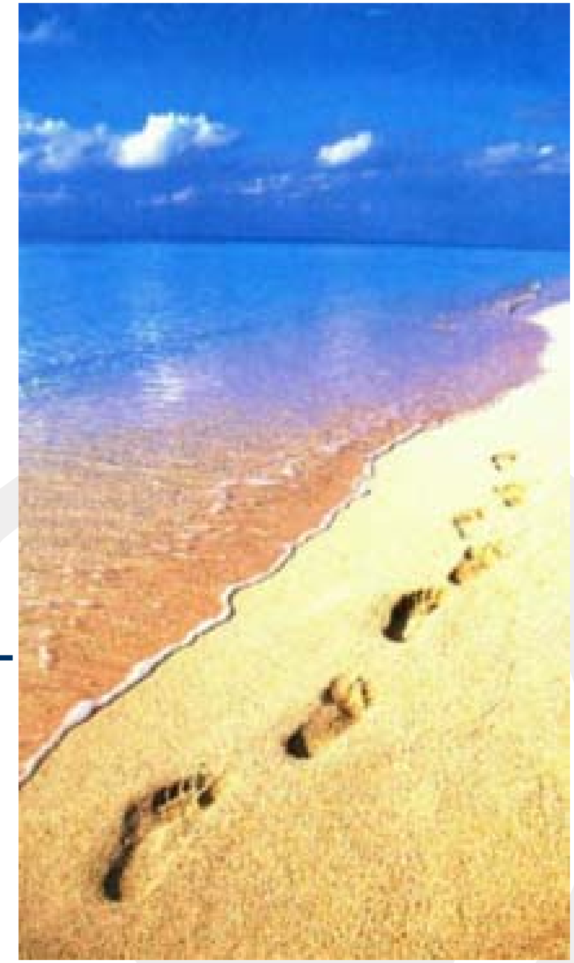
Improvement opportunities





Reduction options

Option	Change in efficiency*	GGE reduction (%)
Incremental improvements	36→38	5
Replacement		
Old coal with new	26→40	25
Supercritical pf	36→40	10
Ultrasupercritical pf (now)	36→42	15
Ultrasupercritical pf (future)	36→50	30
Emerging IGCC *etc*	36→50	30
Flyash to cement		5-7
Biomass-coal		5-15
Solar-coal		10

** gross, sent out*

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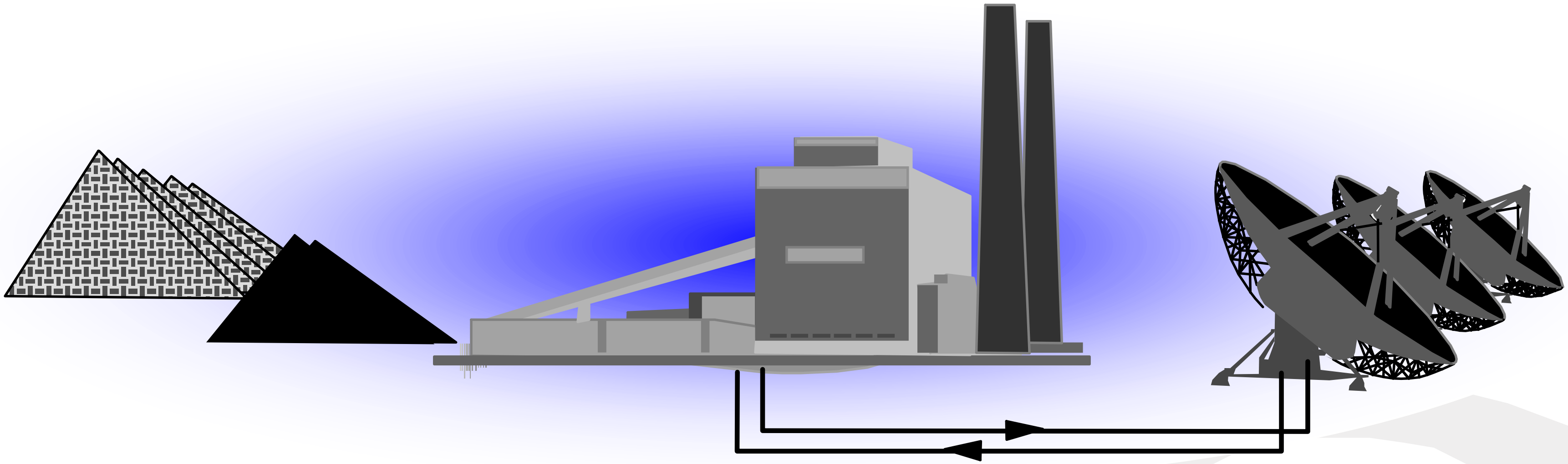
Synergies with renewables



Biomass co-firing

35% biomass conversion efficiency (20% for dedicated)

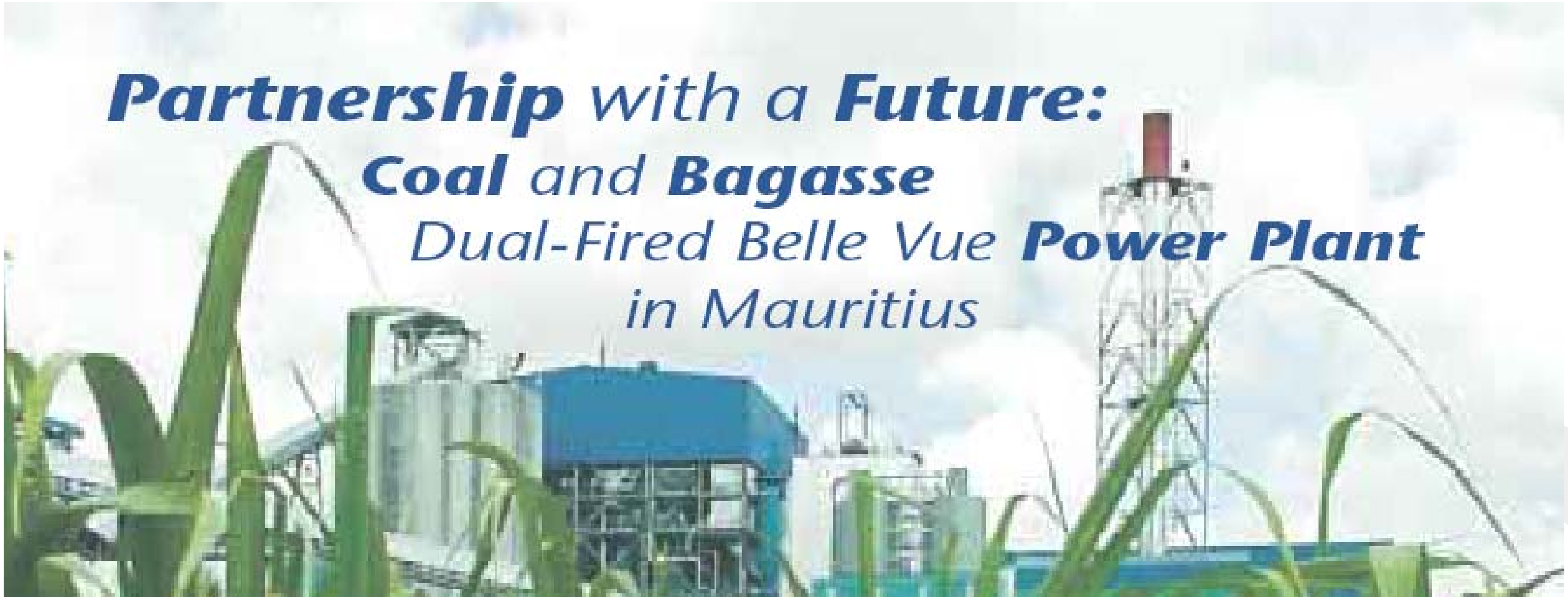
Solar thermal

30-40% solar conversion efficiency (13% for PV)

Coal can promote uptake and efficient use of renewables

Coupling of renewables and fossil energy research is essential

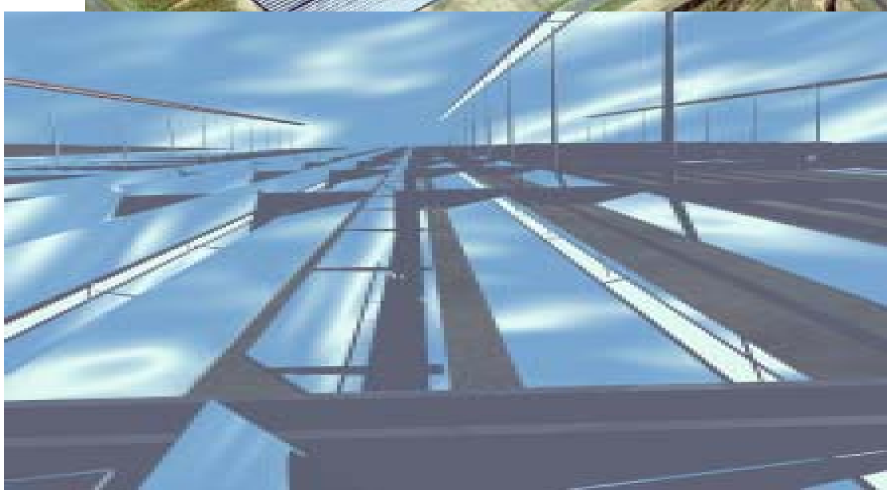
Biomass-coal generation



- **Guadaloupe, Reunion and Mauritius have installed 6 X 70 MWe dual fuel power stations:**
  - **bagasse (6 month season)**
  - **coal (when bagasse unavailable)**
- **Provide electricity throughout year, while maximising use of renewable energy (biomass)**
  - **economic and social benefits**
  - **enables more efficient plants to be built**

Source: Good News from Coal, WCI, Nov 1999

Solar-coal generation



- Several technologies have been proposed
  - 130 MW_e per km^2
- Lowest cost routes to solar electricity
  - A$80/MWh @ 100$MW_e$
- Demonstration plant of 3MW_e (av) under consideration

CDM - extending the value chain

- Growing importance in life with coal
  - many opportunities for the coal industry
  - need to build mechanisms to identify and progress

CBM/MVA

Repowering

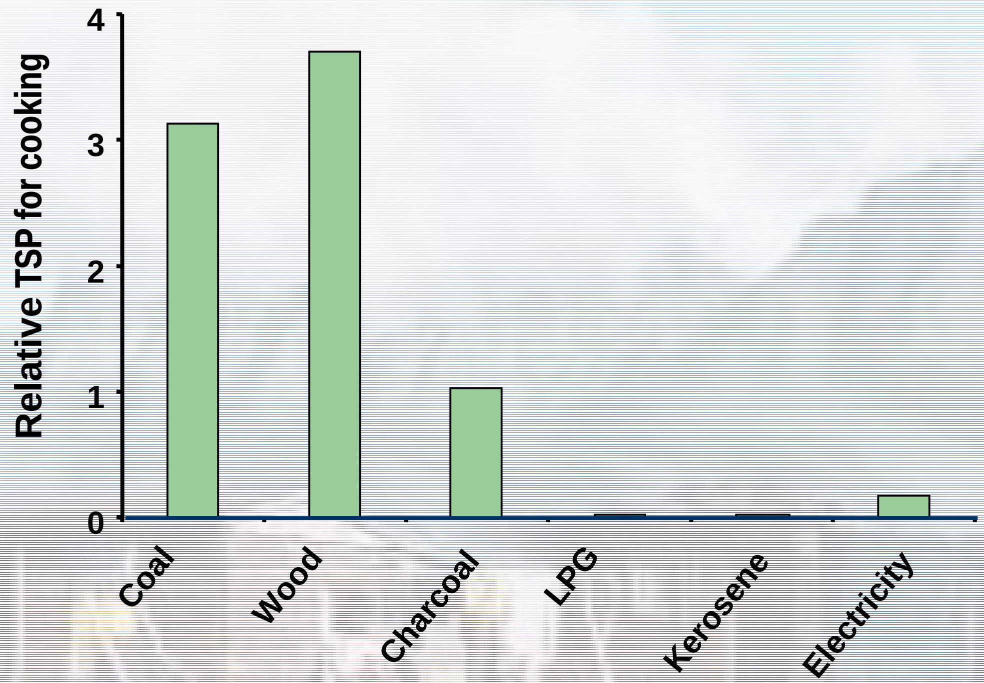
Co-firing biomass

Other issues?

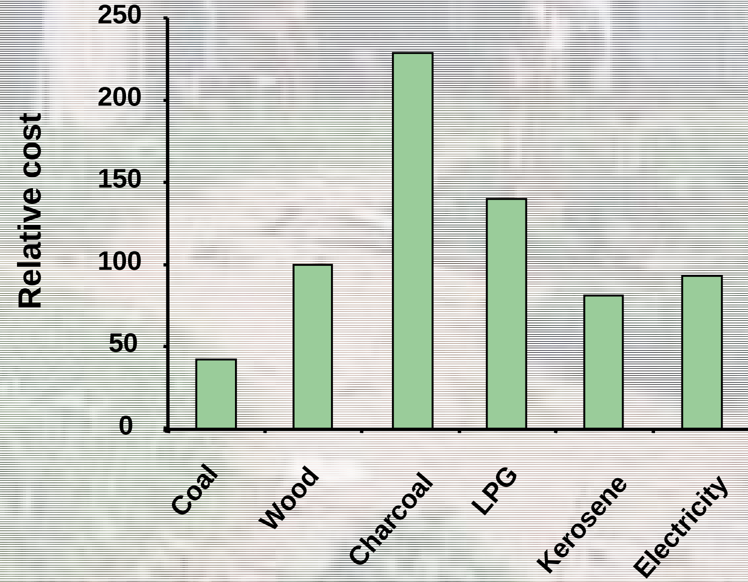
Time Magazine July 2001

- Small scale direct use of fuels is causing major problems in some parts of the World
  - As/F in China
  - particulates in RSA/China
  - Mine safety issues
  - adverse perceptions of life with coal

Direct use of solid fuels - TSP



- Particulates are a major health issue in South Africa and China
  - cooking and heating
- Powering with grid electricity the solution
  - similar costs in some cases



Water consumption (indicative)

Product/service	Water consumption
Coal fired power (m^3/MWh_e)	2
Steel (m^3/t cast steel)	2.5
Wood (m^3/m^3)	400
Wheat (m^3/t)	1,000
Rice (m^3/t)	1,500
Household (m^3/person/year)	70

- Australians need 1 million litres of fresh water per person per year (ABS 1996-97)
  - includes industry and food production
- Life with coal will require increased attention to water issues - both consumption and contamination

Power generation – water use

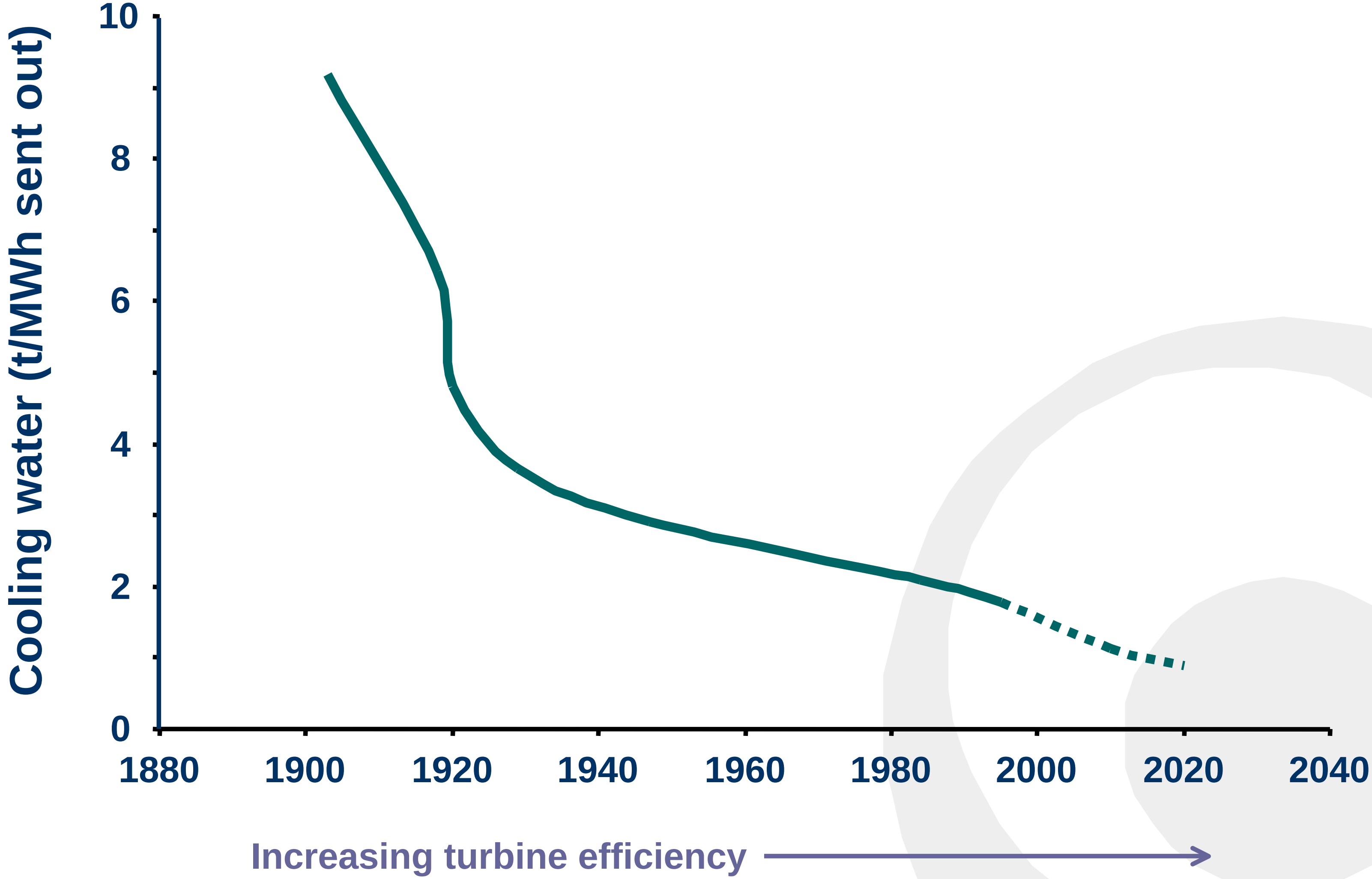
- Water consumption for power generation depends upon the cooling technology used and the efficiency of the conversion of steam to electricity in the turbine

Majuba power station in South Africa

	Water consumption (m^3/MWh)	Efficiency (%)
Units 1-3 (dry cooling)	0.2-0.4	~33
Units 4-6 (wet cooling)	2.0-2.5	~37

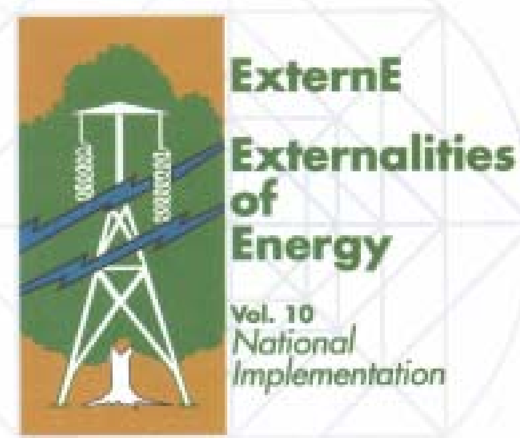
Source: African Energy Vol.1, No.3, 1999

Power generation – water use history



ExternE – costing of externalities

- Started as EC and USA Fuel Cycles Study in 1991
  - evaluation of external costs associated with fuel chains
- 1993-1995, continued as Externe project
  - 40 European institutes (9 countries)
  - USA scientists involved
- Methodology developed for quantifying environmental and social impacts and costs associated with production and consumption of energy
  - used to evaluate external costs of incremental use of different fuel cycles in EU countries



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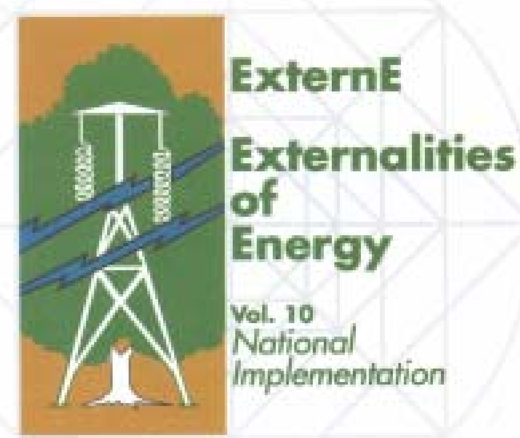

ExternE for coal-based electricity

Europe (mECU/kWh)

Economy	YOLL				Global warming GHG mid 3%	All other	Total	Comments
	NO_X	SO_X	TSP +Other	Total				
UK	6.1	10.5	2.9	19.5	15	7.5	42	UK deep mine, PF, ESP, FGD Low NO_X, no SCR
Germany	6.3	2.9	1.2	10.4	14.3	5	29	DENOX, FGD
Sweden	0.079	0.366	0.036	0.481	13.2	4.419	18.1	SCR for NO_X > 90% reduction, FGD for SO_X > 88% reduction, Electric filter for PM > 99% reduction, cogeneration

YOLL = Years of life lost converted to economic terms

Other = includes morbidity costs of TSP, SOx & NOx, and accidents (accidents minor contributor)

All Other = cost of impacting crops, ecosystems, materials, noise, aquatic systems & aesthetics

Mid 3% GHG: A discount rate is applied to future impacts of global warming events

EUR 18528 – ExternE- Externalities of Energy Vol. 10 National Implementation

Final remarks

- Many opportunities for improvement throughout the coal chain, for both iron and steel, and electricity generation
  - a systems approach is required to identify these
  - many include product stewardship - which provides opportunities for all participants
- Substantial improvements are available through "incremental" changes to "conventional pf" technologies and new technologies
  - by 2015, improvements in efficiency will enable reductions in resource consumption, GGE and water use by 30%
- Coal will underpin the use of renewables for electricity generation
  - need to couple renewables and fossil fuel R & D
- CDM
  - opportunities along the value chain

Final remarks

Life with coal will continue to pose challenges, while at the same time providing energy security, supporting economic development and underpinning the development of renewables